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13. ABSTRACT *(Maximum 200 words)*

Research under this continuing grant is broadly devoted to discovering and characterizing new electronic and optical devices, and demonstrating their use for novel and critical applications. Theoretical and experimental progress on photonic bandgap structures holds promise for important advances in photonics. Progress in quantum circuit theory and self-assembly of nanoscale structures can be expected to advance the frontiers of nanotechnology. Studies in ultrafast optics offer new ways to characterize the electronic response of materials.

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Professor Daniel Kleppner, Principal Investigator
Research Laboratory of Electronics
Massachusetts Institute of Technology

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1. Statement of the Problems Studied

The primary objective of this project is to discover and characterize new electronic and optical devices, and to demonstrate how these may be used in novel and critical applications. Theoretical and experimental progress on photonic band gap structures holds promise for important advances in photonics. Progress in ultrasensitive capacitance spectroscopy, quantum circuit theor, and self-assembly of nanoscale structures can be expected to advance the frontiers of nanotechnology. Studies in ultrafast optics offer new ways to characterize the electronic response of materials. Advancing measuring techniques based on atom optics and coherent atom techniques with Bose-Einstein condensates provide a new frontier for atom manipulation and ultrasensitive measurements.

2. Summary of the Most Important Results

Primary research results from this project include the following:

The optical properties of Bose-Einstein condensate were characterized, leading to the discovery of a new form of superradiance, which became the essential element in the realization of a phase-coherent matter-wave amplifier.

A novel scanning microscope was developed that creates images of the quantum Hall state by sensing charges in the 2D system. The apparatus, operating at 0.3 K, is so sensitive that it can detect single electrons in the 2D layer.

The asymmetric Fano line shape in the Kondo regime was calculated using the slave-boson and Hartree-Frock method.

A novel technique for scaling the output power of femtosecond lasers was developed and demonstrated, and the world's record for the shortest laser pulses ever generated directly from a laser, a duration of 5.5 fs, was achieved.

A new semiconductor alloy was designed that possesses a direct bandgap at optical fiber communication wavelengths.

A novel "dual-hardmask" process was developed, enabling fabrication of channel-dropping filters and similar grating-based optical devices.

It was demonstrated that a semiconductor mirror providing two-photon absorption in a harmonically mode-locked fiber laser introduces a fast intensity-dependant loss that can equalize pulse energies and reduce pulse dropouts.

Interference lithography and spatially-phase-locked e-beam lithography were used to generate integrated Bragg gratings in materials that are not photo-reactive.

3. Listing of Publications and Technical Reports

(a) Papers published in peer-reviewed journals

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Fujimoto, J.G., "Biomedical imaging using optical coherence tomography," Conference on lasers and Electro-Optics CLEO'98, San Francisco, CA, May 3-8, 1998, (invited) plenary paper JMA3.

Fujimoto, J.G., "Optical coherence tomography for medical imaging and diagnosis," XVI International Conference on Coherent and Nonlinear Optics, (ICONO'98), Moscow, Russia, June 29-July 3, 1998, Paper FB1, Keynote address.

Fujimoto, J.G., "Optical Coherence Tomography for Biomedical Imaging," First International Conference on Ultrasonic Biomedical Microscanning, Eastwood Park, UK, September 1-4, 1998, Keynote address.

Fujimoto, J.G., "Biomedical Imaging using Optical Coherence Tomography," Fourth Annual Symposium on Frontiers of Engineering, National Academy of Engineering, Irvine, CA, September 17-19, 1998, invited presentation.

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Lim, K.-Y., D.J. Ripin, G.S. Petrich,. L.A. Kolodziejski, E.P. Ippen, M. Mondol, H.I. Smith, P.R. Villeneuve, S. Fan, and J.D. Joannopoulos, "Photonic Bandgap Waveguide Microcavities: Monorails and Air-Bridges," presented at the 17th North American Conference on Molecular Beam Epitaxy, October 4-7, 1998, Pennsylvania State University, PA.

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M. E. Grein, E. R. Thoen, E. M. Koontz, H. A. Haus, L. A. Kolodziejski, and E. P. Ippen, "Stabilization of an active harmonically mode-locked fiber laser using two-photon absorption", Paper presented at the 2000 Conference on Lasers and Electro-Optics, San Francisco, California, May 7-12,2000.

4. Listing of Scientific Personnel and Earned Advanced Degrees

(c) Principal Investigators

Allen, J.
Ashoori, R.
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Mochrie, S.
Pritchard, D.
Smith, H.

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(d) Other Personnel

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Durfee, D.
Erchak, A.
Ferrera, J.
Goldhaber-Gordon, D.
Holley, J.
Ivanov, D.
Koltonyuk, M.
Lim, K.
Lim, M.
Lumma, D.
Murphy, T.
Patterson, S.
Rubenstein, R.
Stamper-Kurn, D.
Thoen, E.
Wang, Y.

(e) Advanced Degrees Earned

David Berman, The Aluminum Single-Electron Transistor for Ultrasensitive Electrometry of Semiconductor Quantum-Confined Systems, Ph.D. diss., Dept. of Electr. Engin. and Comp. Sci., MIT, 1998.

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